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SYSTEM AND METHOD FOR SIMULATING AUDIO COMMUNICATIONS USING A COMPUTER NETWORK

TECHNICAL FIELD OF THE INVENTION

This invention relates to the use of computer systems for simulating real world situations, and more particularly to the use of a computer system to simulate audio communications.

BACKGROUND OF THE INVENTION

As the demand for simulation-based training and testing systems increases, so does the demand for more realism. A realistic simulation system should comprise

5   at least three components: visual realism, tactile realism, and aural realism. Many tools are available that are directed to the first two components, but the aural component of realism is often given short shrift. As a result, many simulation systems provide a simulated

10   environment with a great "look and feel", but lack a meaningful aural experience.

As an example, a high level flight simulator might realistically simulate the cockpit of an aircraft and the feeling of flying. However, voices and other sounds

15   attempted to be reproduced in the pilot's headset are not likely to sound like those actually transmitted over a radio channel. In such a system, the trainee pilot's ear is not being trained at the same level as his or her visual and tactile senses.

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BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

FIGURE 1 illustrates a simulation system in accordance with the invention.

FIGURE 2 illustrates the programming architecture residing on the server of FIGURE 1.

DETAILED DESCRIPTION OF THE INVENTION

FIGURE 1 illustrates a system 100 for simulating audio communications in accordance with the invention. The audio simulations provided by system 100 are

5   significant to the simulation industry, but are also applicable in other fields, such as in the communications industry. With respect to the latter, by using discrete modules to simulate communications alternatives, the communications industry can make better decisions about

10   which systems best meet design criteria.

An example of aural realism provided by the invention is the replication of the sound of a UHF channel used in a flight simulation system. In this example, system 100 is used to accurately simulate voices

15   that are received by a pilot over a UHF radio channel.

As explained below, in one embodiment of the invention, the system is a client-server-client system. Any client can be a source and/or a destination. The server routes audio between the clients and introduces

20   impairment effects as prescribed by simulation models and parameters. A source client is used to receive audio communications. The audio input is sampled and delivered to the server where it is filtered and injected with random noise and other effects, using digital signal

25   processing (DSP) models. The impaired voice data is then delivered to a destination client.

In real time applications, the audio distribution is real-time for maintaining the interactive fidelity of a training environment. In playback applications, the

30   audio may be processed and recorded prior to playback.

Some applications might use a combination of real-time and playback audio.

Real-time applications may use live participants, with some speaking into microphones and others listening
5   through speakers to audio that is impaired in accordance with the invention. A playback application would permit "virtual participants" to participate in the simulation and deliver impaired audio to one or more live recipients via headphones.

10   System 100 may provide simulations of various audio transceivers, operating over wireless, metal wired, or fiber optic wired channels, or any combination of these. Each of these transmission mediums has unique audio characteristics, which are modeled by system 100. The
15   simulated transceivers appear in many applications, mobile or stationary. Examples of transceivers includes those associated with aircraft, ground vehicles, or communications centers.

System 100 is a distributed computer network system,
20   having at least one server 101 and a number of client stations 102 and 103. Server 101 receives audio data from one or more transmitter client systems 102, applies DSP models to the data, and delivers the processed audio to one or more receiver client systems 103. Client
25   systems may also be two-way (transceiver) systems, such as client systems 104 and 105 which send and receive audio. Although only four client systems are illustrated, system 100 may handle any number of client systems as is appropriate for its processing capacity.

30   For purposes of this description, a "transmitter client" may be client system 102 or client system 104 or

105 when they are transmitting audio. Similarly, a "receiver client" may be client system 103 or client system 104 or 105 when they are receiving audio.

5   In typical applications, such as flight simulation, the system 100 operates in real time with two-way clients. Live participants will transmit and receive audio data, via their respective client systems and the server 101. Any number of participants tuned to the same channel can send and receive audio.

10   Client systems 102 - 105 have appropriate hardware and software for sampling input audio and playing received audio data. Client systems may be conventional personal computer type devices, including laptops and PDA's, equipped with conventional off-the-shelf sound
15 cards and player devices, including microphones and speakers. Depending on the application, headphones (as illustrated in FIGURE 1) rather than speakers may be used.

      Server 101 is equipped with microprocessing devices,
20 programmed to perform the tasks described herein. Server 101 also performs standard computer server functions, such as receiving and satisfying requests for data from clients 102 and 103.

      FIGURE 2 illustrates the programming residing on
25 server 101. As illustrated, the processing of audio data is performed by server 101, which relieves client systems 102 and 103 of that processing burden.

      In the example of this description, server 101 is in data communication with clients 102 and 103 via an
30 Ethernet connection. Thus, network 104 is a local area network. However, the same concepts could be applied to

a wide area network, such as one using a TCP/IP protocol.
The communications links of network 104 may be wired or
wireless. Each client 102 or 103 is equipped with a
network interface card for data communications over

5   network 104. A 100 Mbps Ethernet connection is an
example of a suitable data speed. Various methodologies
and protocols may be used for communicating the audio
data across the network. An example of a suitable
protocol is VoIP (voice over Internet Protocol).

10   Transmitting client 102 receives and stores sampled
audio data. As an example, client 102 may be equipped
with a microphone and soundcard (printed circuit board)
for receiving and sampling (digitizing) spoken words.

          Client 102 then delivers the sampled audio data to

15   server 101 via network 104. In the example of this
description, data communications are via data packets.
Server 101 processes the audio data by applying the
simulation models of engine 21.

          Server 101 determines which receiver clients 103 are

20   to receive the processed audio data, then delivers the
audio data to those clients 103. Client 103 is equipped
with a soundcard (printed circuit board), which it uses
to convert the processed audio data to analog data, which
is played to the user of client 103, using headphones or

25   speakers.

          Client systems 102 - 105 may be conventional
computer workstations, having conventional processing and
memory capability. As explained above, the special
equipment for implementing the present invention includes

30   audio equipment such as speakers, microphones, and sound
cards.

Referring specifically to Figure 2, which
illustrates the programming architecture of server 101,
server simulation programming 20 resides on server 101.
This programming 20 oversees the operation of the audio

5   simulation engine 21 (including impairment models and
transceiver models discussed below), application
interface 24, and the server-side graphical user
interface (GUI) 25. Depending on the sophistication of
the simulation programming, the audio simulation engine

10   21 may be used in conjunction with a tactile simulation
engine 22 and/or a visual simulation engine 23.

The transceiver models and impairment models of
audio simulation engine 21 are implemented with DSP
(digital signal processing) programming. The DSP

15   functions may be implemented with the main CPU of server
101, or optionally, with special DSP devices operating in
conjunction with the CPU of server 101.

In general, the transceiver and impairment models of
engine 21 are created by analyzing a real world

20   communications system and its effects on transmitted
signals. Their processing is used to model
characteristics of real world radio communications
channels. The processing is then used to impose those
characteristics on a signal, so that the signal simulates

25   a signal that was transmitted through those channels.
Thus, the model is used to replicate the sound at the
output end of a radio communications channel.

Transceiver models model the type of radio or other
transceiver being simulated. Typically, both the

30   receiving and transmitting client systems are transceiver
systems, but in certain embodiments, a transceiver model

could be of a receiver-only or transmitter-only equipment. A transceiver model may be as simple as a bandpass filter. The transceiver power is an example of one parameter to the model.

5   Transceiver models include models of automatic gain control circuits and squelch circuits. Signal sensitivities (how low a signal can be received) are used for modeling these circuits. Bandpass filters are used to model the frequency response of a transceiver.

10   Impairment models model the effects of the transmission medium, such as by modeling channel fading, multi-path fading, propagation delay, noise (including Gaussian), Doppler shift effects, and gain control. For wireless communication simulations, in addition to

15   filtering and noise injection, the impairment models also simulate the effects of line-of-sight, propagation losses, signal fading, and other effects characteristic of wireless communications. The impaired audio could include any desired background noise, in addition to the

20   communicated voice audio, such as engine noise, wind noise, artillary noise, etc.

A feature of the invention is that the impairment models may operate dynamically, in response to simulated conditions. For example, for simulating aircraft audio

25   communications, an aircraft may be flying at a certain speed and be a certain distance away from a control tower with which it is communicating. The speed and distance may be used as parameters to the model, which will process the audio data differently depending on these

30   parameters. For purposes of this description, parameters such as speed and distance of a client system (i.e., a

simulated aircraft) are referred to as "dynamic simulated entity data".

Multipath impairment models use as input, the velocity of the entity (aircraft, vehicle, etc.) that is receiving the transmission and the radio frequency. Doppler effect impairment models use the velocity and the angle between the transmitter and receiver. Channel noise models use an additive Gaussian white noise generator whose level is controlled by the path gain. Path gain is represented as a fraction of signal power based on the distance between the transmitter and receiver, the power of the transmitter, and the carrier frequency.

As an alternative to sampling real world audio input, the models of server 101 could be used to generate audio data. Various techniques for artificially generating voice and other audio sounds could be used.

The application program interface (API) 24 controls the interaction of the audio simulation engine 21 and the visual and tactile simulation engines 22 and 23. The API 24 operates in conjunction with the tactile simulation engine 22 so that tactile entries made at a client system 102 - 105 may be used to control the audio simulations. For example, an operator at a client system may select a particular simulation environment, which includes a particular type of transceiver. Additional tactile selections by the operator could include channel and volume settings or any other type of control found on a radio or other audio equipment. The API 24 may also be used to provide visual displays to correspond with the tactile selections and the audio environment. For

example, a visual display of a radio console could be used to depict controls (such as switches, knobs, and indicator lights) for volume, noise level, signal strength, or other audio qualities, or to depict current

5   levels of these qualities.

In the case where programming 20 includes visual and tactile simulation engines 22 and 23, client systems 103 - 105 would then have appropriate graphical user interfaces for providing these visual displays and

10   receiving tactile inputs. However, a feature of the invention is that the audio processing of engine 21 is performed at the server, which permits system 100 to be implemented with a minimum of processing at client systems 102 - 105. Specifically, for purposes of

15   implementing the audio simulation provided by engine 21, client systems 102 - 105 need only a sound card, and speaker and/or microphone and whatever software is required to receive and play audio data.

The interrelated audio, visual, and tactile

20   simulations described in the preceding paragraph relate to simulated communications and related hardware. System 100 and programming 20 may be further enhanced to include (or work in conjunction with) additional simulation not related to audio. For example, in the case of a flight

25   simulator, these additional controls might include flight controls and cockpit views.

Graphical user interface (GUI) 25 is used to configure and control the simulation engines 21 - 23. A system administrator will specify the models used for a

30   particular simulation, as well as various impairment parameters, and other operational characteristics.

System 10 and its programming can be fully implemented using a combination of conventional computing devices and conventional programming languages and tools. The programming described herein can be implemented with

5   C++ language to enhance its ability to interface with existing non-audio simulation systems.